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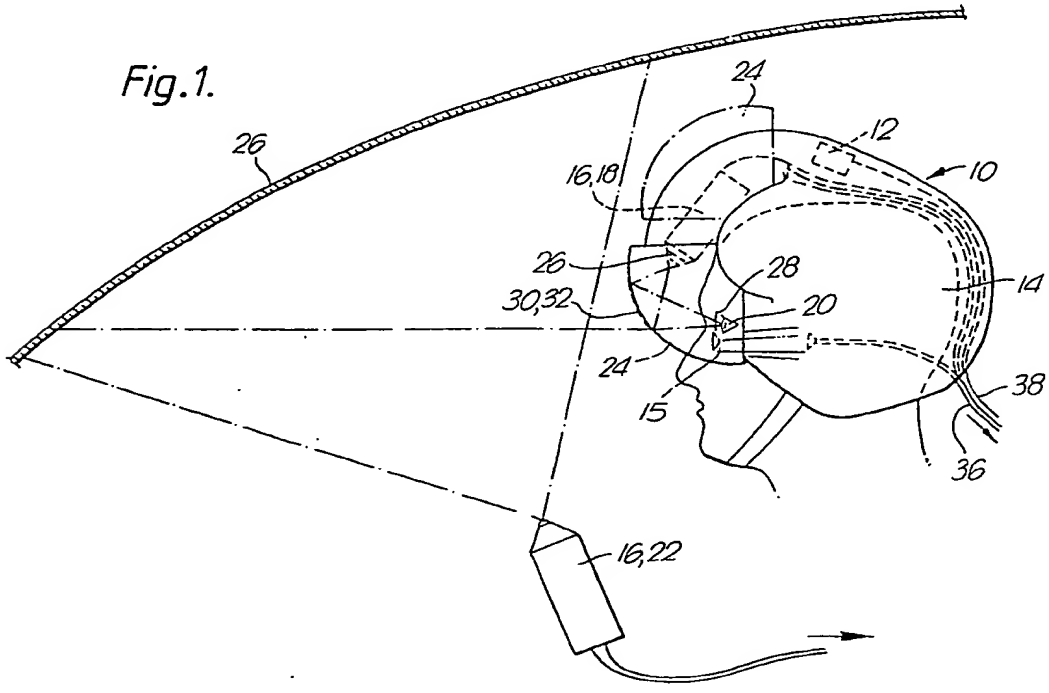
(54) Variable resolution view-tracking display

(57) A panoramic display apparatus 10 mounted, at least in part on a helmet 14 to be worn by an operator, in which apparatus there is a projection means 16 for projecting a high resolution stereo display within a small first field of view containing the foveal line of sight of an operator's eyes and a low resolution display outside said first field of view. The high resolution first field is used to present a detailed image of the object the operator is looking directly at whilst the low resolution field presents a low resolution peripheral image in the areas where the operator's eyes are incapable of perceiving high resolution images. One or other or both displays may be projected onto an eyeshield 24 or displayed via one or more active matrix liquid crystal displays which may be mounted on or form part of the eyeshield 24.

The apparatus may be used with flight or other simulators, remote control apparatus e.g. robots, surface or space vehicles. Alternatively the apparatus may be combined with cameras to give an aircraft pilot an "all-round" view (fig 6).

Fig.1.



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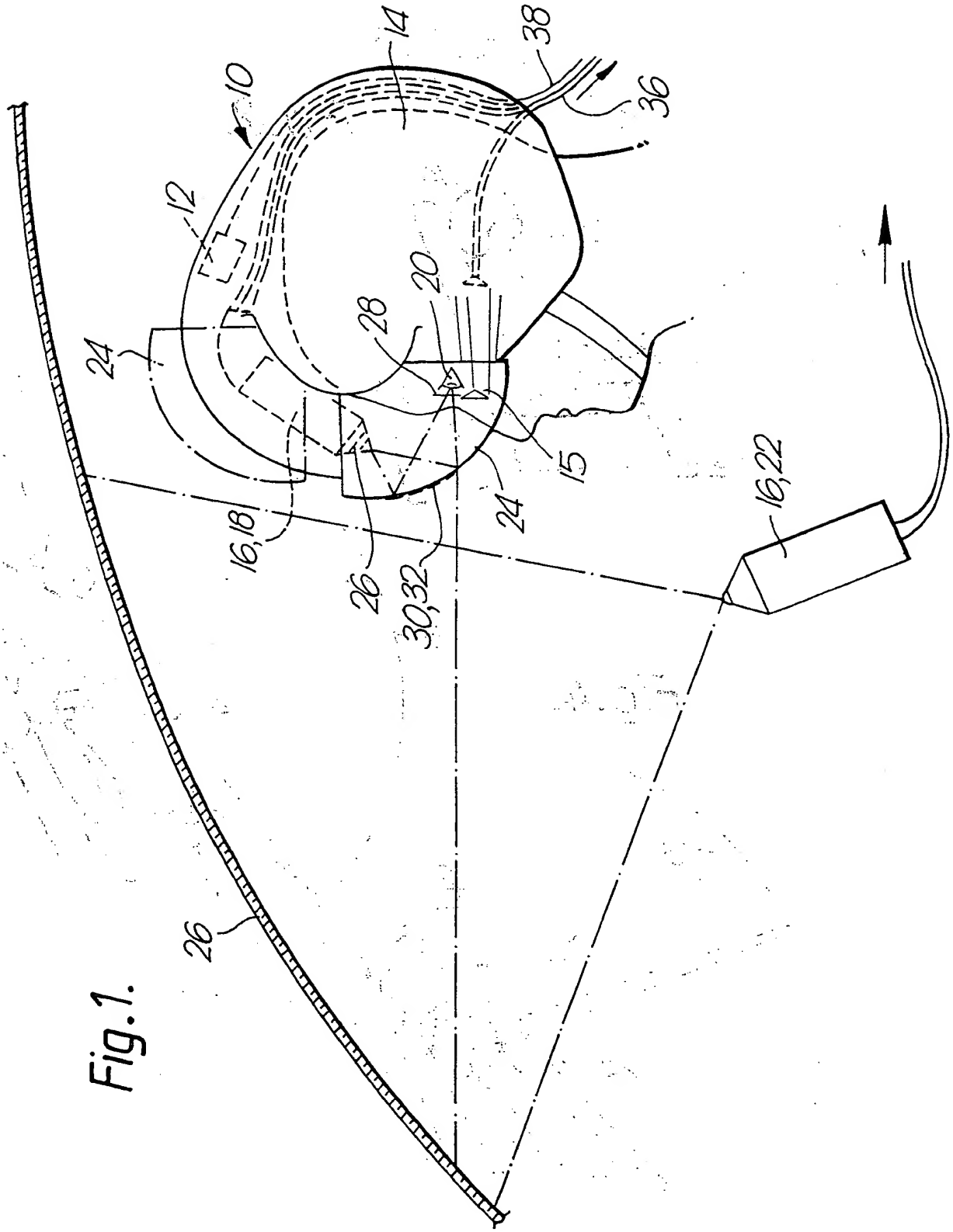


Fig. 1.

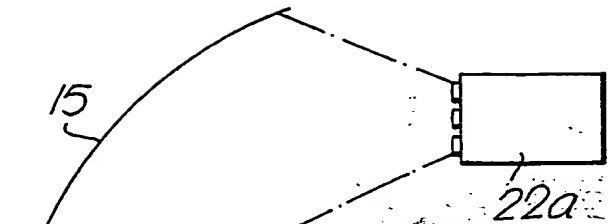


Fig. 2.

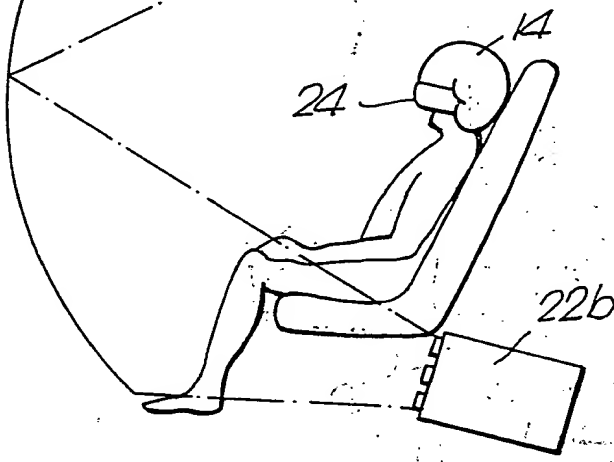


Fig. 3.

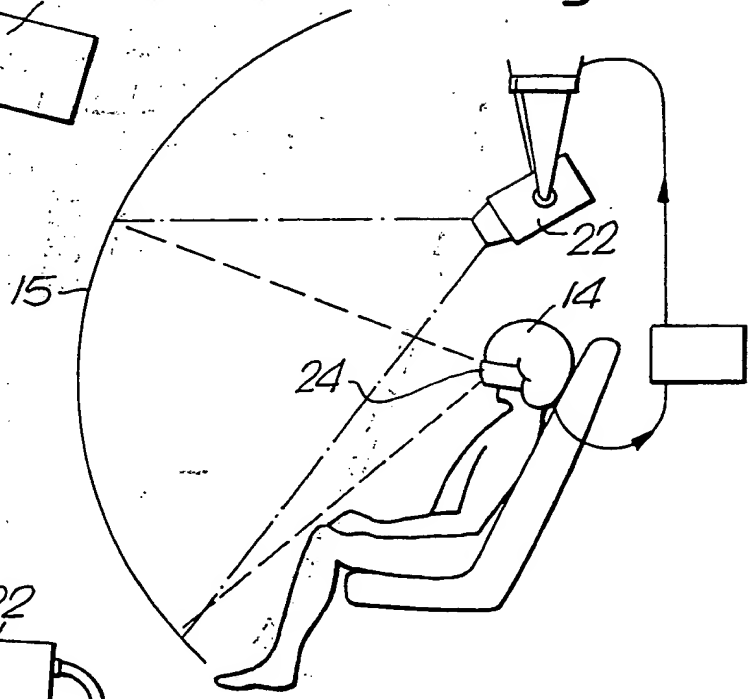
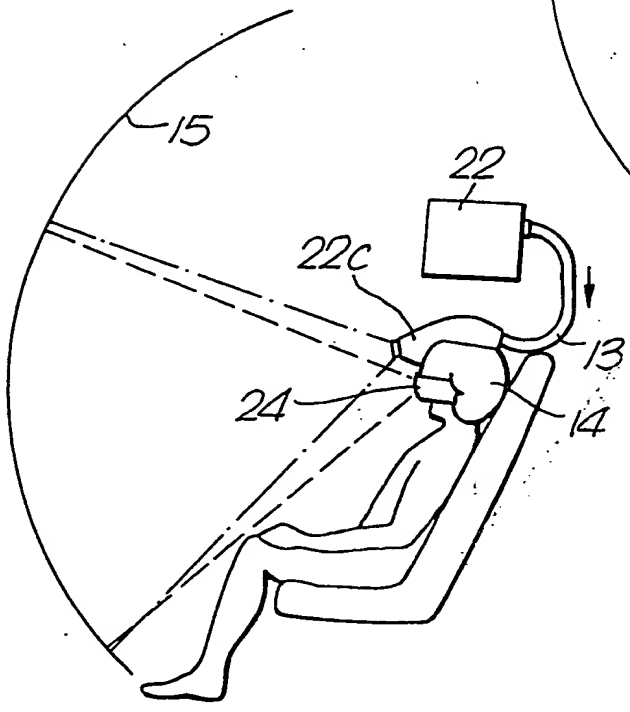


Fig. 4.



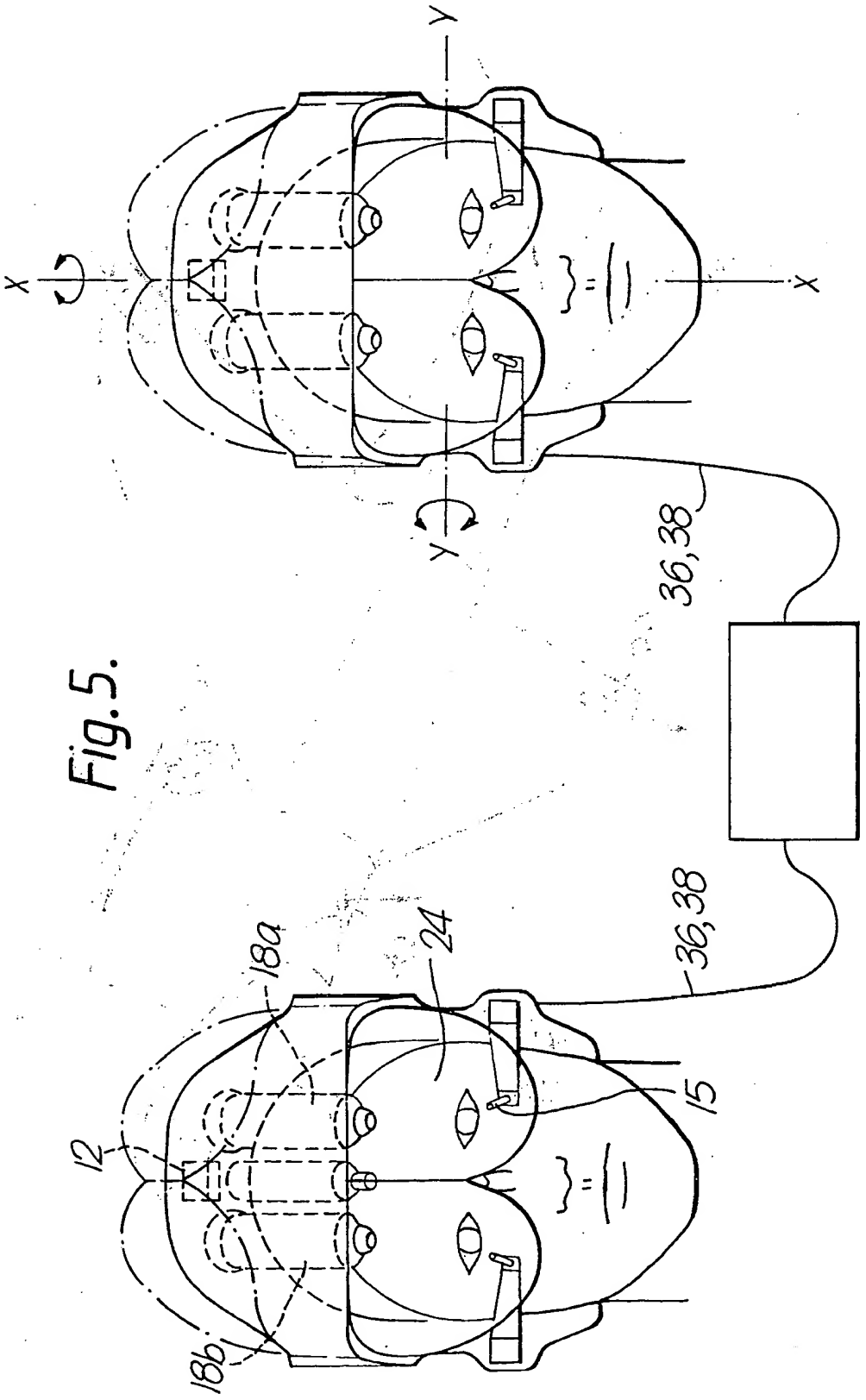


Fig. 5.

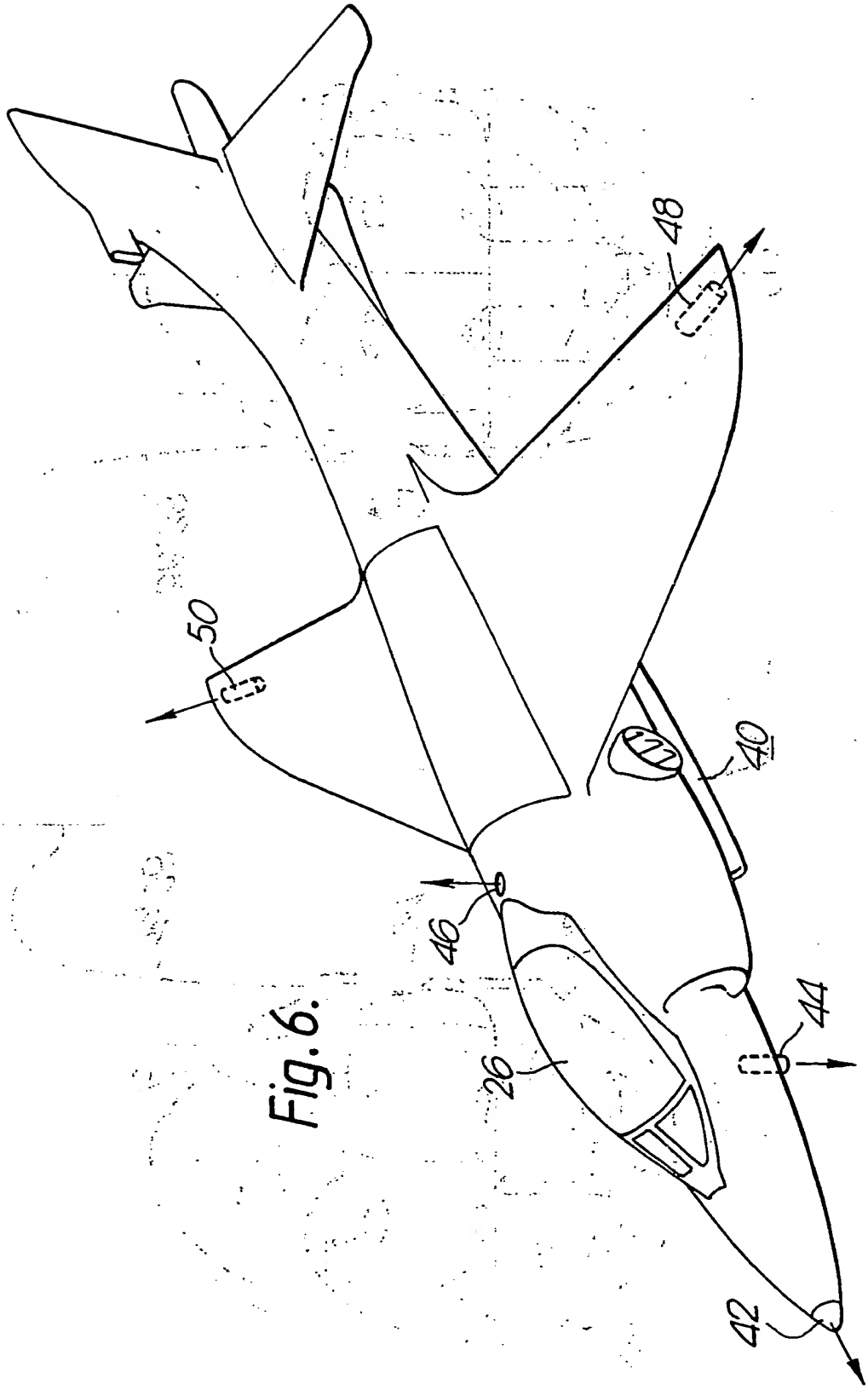


Fig. 6.

AN EYE-SLAVED PANORAMIC DISPLAY APPARATUS

The present invention relates to an eye-slaved panoramic display system and relates particularly, but not exclusively, to such an apparatus for use in applications that require remote or synthetic visual contact with the environment such as vehicle control, remote piloting, telerobotics and simulation.

Presently known systems for outside-world representation generally employ one of three methods for image display, namely: direct view monitor, video projection or, head/helmet mounted display (HMD). Direct view monitors, such as cathode ray tubes (CRT's), offer reasonably high image resolution and are a popular display technique, both for sensor-derived and computer-generated images but they offer only a comparatively narrow field of view. The field of view can be increased by increasing the screen size but this cannot be done above a certain diameter without reducing image resolution or refresh rate. This can also be prohibitively expensive and can incur unacceptable size and weight penalties.

Video projection systems that employ multi-screen or dome-wall video projections can provide a large instantaneous field of view which in many cases is truly panoramic with over 120° of view. Such systems provide the viewer with valuable peripheral information as well as a more realistic viewing area and, consequently, have become very popular in the field of flight simulation. These systems suffer from the problem of reduced image quality because the gain in field of view is

obtained by simply expanding the original image across a larger surface at the expense of image quality (resolution and contrast).

The ESPRIT projector-based systems proposed by Singer-Link provides a so-called area-of-interest (AOI) visual simulator. In this system a wide-angle low resolution image is projected onto a simulator dome and is overlaid with a higher resolution, but smaller, eye-slaved image, provided by a separate servo-driven projector. Such a system does not lend itself to stereoscopic image presentation, nor to use by multiple viewers.

Head or helmet mounted display systems are being developed which present a condensed CRT-type image onto a head or helmet mounted eye piece. These can offer high resolution and with appropriate viewing conditions, good luminance contrast. The images are normally head-slaved (and could also, in theory, be eye-slaved) so that the wearer is able to guide his/her direction of gaze through a total potential field of view of up to 360°. In addition HMD systems can also provide binocular stereopsis, something which can only be approximated with direct-view and projection displays. Unfortunately the field of view provided by HMD systems is relatively small (eg 60° binocular FOV, including 40° per eyepiece) and increasing the field of view without loss to image quality is prohibitively expensive in terms of image generation/conversion.

None of the above mentioned systems is capable of providing a suitably sharp stereoscopic image with a large general viewing area without impairment of image quality or without overstretching the image generation/conversion systems.

It is therefore an object of the present invention to provide a panoramic display apparatus which mitigates the problems associated with the above mentioned systems.

Accordingly the present invention provides a panoramic display apparatus comprising a head position tracking device and an eye position tracking device which in combination enable an operator's foveal line of sight to be determined, means for dividing an operator's field of view into a first field containing an operator's foveal line of sight and a second field outside said first field, and projection means for projecting a high resolution display within said first field and a low resolution display in said second field.

It will be appreciated that the above mentioned apparatus exploits the limitations of the human eye, which is incapable of perceiving high resolution images outside a narrow (approximately 5°) cone around the foveal line of sight, and provides a panoramic display apparatus that gives high image resolution only where the operator's eye is capable of perceiving it and a low resolution display outside this field. Such an apparatus is capable of providing a suitably sharp image with a large viewing area without impairing image quality and without over-stretching the image generation/conversion system.

Preferably, the apparatus includes an eyeshield of an operator's helmet onto which the high resolution display is projectable and a remote surface onto which the low resolution display is projectable.

Alternatively, the apparatus includes an eyeshield of an operator's helmet onto which the high and/or low resolution displays are projectable.

Conveniently, the above mentioned remote surface may be the interior surface of an aircraft canopy (or some other workspace interior).

The projection means may comprise a first projection system for projecting the high resolution display and a second projection system for projecting the low resolution display. In a particularly advantageous arrangement the high resolution display may be projected onto the eyeshield of an operator's helmet and the low resolution display is projected onto a remote surface such as the interior surface of an aircraft canopy.

In a simple arrangement the first projection system may comprise a first projector which presents an image alternately to both left and right eyes of an operator thereby to give a stereo image.

If just one projector is used in this way, the projection system may include an LCD shutter located at or near a source of said image and passive polarisers before an operator's eyes in order to present the image alternately to both left and right eyes.

Alternatively, the first projection system comprises first and second projectors locatable and operable in combination to present an image to both eyes of an operator in a manner which gives a stereo image.

One or more active matrix LCD arrays may also be used to project the high and/or low resolution displays. The array is/are transparent and locatable to form part or all of an eyeshield of an operator's helmet or is/are mountable on said eyeshield.

Conveniently the first field of view may extend up to or slightly beyond an operator's foveal boundary. Gradation means may be provided for modifying the resolution of the first field at its periphery in a manner which matches or approximates the reduction in image resolution due to the human eye's acuity/eccentricity curve.

Computation means may be provided for computing the visual field location or locations of the high resolution first field or fields.

Conveniently, the first projection system may be mounted on a helmet to be worm by an operator and the second projection apparatus may be mounted remote from said helmet, thereby to enable the low resolution second field projection to be projected onto a remote screen.

In a particularly advantageous arrangement the second field of view extends to form a full field of view of up to 360° about an operator's X and Y axis, thereby to allow the operator to see in all directions including downwards and rearwards.

The above mentioned panoramic display apparatus may be used remotely to pilot a vehicle and/or in a robot/robotic system, thus avoiding exposing the operator to dangerous or inhospitable environments.

Advantageously two or more panoramic display apparatus may be linked to each other to form a network of visual displays for use with multiple operators and different information may be presented to each operator's high resolution first field of view thereby to provide the operators with only that information they require in order to perform their given task.

In a particularly convenient arrangement a helmet may be provided with a panoramic display apparatus as described above.

The present invention will now be more particularly described by way of example only with reference to the accompanying drawings in which:

Figure 1 is a cross sectioned side elevation of an operator's helmet incorporating a panoramic display apparatus according to the present invention and an aircraft canopy,

Figures 2 to 4 illustrate various alternative projector positions.

Figure 5 is a front elevation of two operators helmets incorporating panoramic display apparatus according to the present invention together with associated computation means, and

Fig 6 is a perspective view of an aircraft incorporating a number of features the subject of the present invention.

Referring to Figure 1, a panoramic display apparatus 10 according to the present invention comprises a head position tracking device, such as an accelerometer 12, mounted on an operator's helmet 14, an eye position tracking device in the form of, for example, an infra-red LED oculometer 15 and a projection

means shown at 16. In a preferred embodiment the projection means comprises a first projection system 18 for projecting a high resolution stereo display within a first field of view containing the foveal line of sight of an operator's eye 20 and a second projection system 22 for projecting a low resolution display outside said first field. It will however be appreciated that only one projection system 18 may be used if suitably modified to be able to project both the high and low resolution displays.

The first projection system 18 is preferably mounted on the operator's helmet 14 and arranged to project the high resolution display onto an eyeshield 24 of the helmet 14. The second projection system 22 may be arranged in any one of a number of ways as illustrated in figures 2 to 4 inclusive. In figure 2, the second projection system 22 comprises a number of static projectors 22a, b projecting onto, for example, the inner surface of a flight simulator dome. Alternatively, just one or two wide-angle, multi-axis, servo-drives, projectors may be provided and mounted, for example, above the operators head as shown in figure 3. Figure 4 illustrates yet another arrangement in which static video or laser projector(s) slaved to head-position by means of a flexible fibre optic link to head-position by means of a flexible fibre optic link 13 to the helmet; the images would then pass through a wide-angle projection device 22c mounted on the front of the helmet 14 before being projected on the remote surface 15. In a particularly advanced and compact arrangement, the second projection means may be arranged to

project the low resolution display onto the eyeshield 24 of the helmet 14 alongside the high resolution display (see for example figure 1).

The first projection system 18 may include one or two projectors 18a,b. When just one projector 18b is used the system is further provided with a Liquid Crystal Shutter 26 at the image source and passive polarisers 28 located before the operator's eyes 20. In operation the shutter acts to deflect the source image alternatively to operator's left and right eyes in a manner which, in combination with the passive polarisers 28, acts to present an operator with a stereo high resolution image. When the two projectors 18 are used each may be arranged to project the high resolution image to one or other of an operator's eyes thereby to provide a stereo image.

In a still further alternative arrangement the first projection system 18 is formed by one or more active matrix liquid crystal displays 30, 32 well known in the art and therefore not described herein. With suitable image processing just one display may be used to present both the high and the low resolution fields and the said one display is preferably mounted on or forms part of the eyeshield 24. When two displays 30, 32 are provided it will be appreciated that only that display presenting the high resolution display need be provided on the eyeshield. The display presenting the low resolution display can be provided on or form part of the eyeshield 24 or can be positioned remote from said eyeshield 24 if desired.

When the one or more displays 30, 32 are mounted on, or form part of the eyeshield 24 it or they may be of a transparent type thus allowing the operator to see real images which are present beyond the eyeshield 24, such as, for example, aircraft cockpit instruments and the like or a remotely projected low resolution display.

The oculometer 15, which monitors the eye position, and the head position sensor 12 are each linked to a computation device 34 via cables 36, 38 respectively. The computation device is configured to monitor the outputs from the oculometer and position sensor and determine the direction of the operator's foveal line of sight such that the high and low definition images may be projected relative thereto. Such an arrangement is well known and hence forms no part of the present invention other than to the extent that it enables the present invention to be operated.

In order to exploit fully the limitations of the human eye, which is incapable of perceiving high resolution images outside a narrow (approximately 5°) cone around the foveal line of sight, the computation device 34 is also configured to determine the boundary of an operator's high resolution image perception and define the boundary of the display apparatus high resolution first field relative thereto. Preferably, the boundary of the first field extends up to or slightly beyond an operator's foveal boundary thereby to minimise the size of the high resolution display and maximise the size of the low resolution display and hence reduce to a minimum the computation power required to present the overall image to the operator. It will be appreciated

that the operator's head and eyes will be constantly moving as he observes the display presented before him, consequently the computation means will be constantly updating the position of the first and second fields in order to provide the best possible display to the operator. Reduction in the computation power required to provide the overall display frees computation power to be used to speed up the image update rate thereby providing a more realistic overall image.

In operation, the high resolution first field may be used to present vital information to the operator, such as weapon or aircraft performance information, together with an enhanced view of that portion of the overall display the operator is looking directly at. Portions of the low resolution display may be enhanced in order to attract the operator's eyes to potential targets if desired.

Figure 6 illustrates an aircraft 40 which is provided with a number of remote cameras 42, 44, 46, 48 and 50 respectively set for forward, downward, upward and left and right viewing respectively. These cameras may be linked into the panoramic display apparatus 10 to provide the pilot operator with outside world visual information in all directions, including directions he would normally be unable to see. It will be appreciated that a pilot operator of an aircraft equipped with such cameras and display apparatus will be able to look down by rotating his head about axis Y-Y towards the cockpit floor for example and see a representation of the real world image on the other side thereof thus enabling him to make visual contact with landmarks or

aircraft normally outside his field of view. If the pilot operator rotates his head about axis X-X he will be able to make visual contact with landmarks etc to his left and his right as well as behind the aircraft if a suitable remote camera if provided to point in this direction. The computation means may be configured to be selective with the outside world information it presents to the pilot operator, thus preventing him from being distracted by irrelevant detail.

An aircraft when provided with the above mentioned cameras and suitably modified to enable remote operation of the aircraft controls to be achieved lends itself to being remotely piloted by a pilot operator using a panoramic display apparatus 10 as described above. The operator would be provided with all the visual information he requires in order to fly the aircraft 40 without being exposed to the often hostile environment the aircraft is flown in.

It will be appreciated that whilst the panoramic display apparatus 10 has been described with reference to use on aircraft it also lends itself to use with manned/unmanned surface vehicles and submersibles, robotic systems in nuclear power plants and teleoperation in space.

CLAIMS

1. A panoramic display apparatus comprising a head position tracking device and an eye position tracking device which in combination enable an operator's foveal line of sight to be determined, means for dividing an operator's field of view into a first field containing an operator's foveal line of sight and a second field outside said first field, and projection means for projecting a high resolution display within said first field and a low-resolution display in said second field.

2. A panoramic display apparatus as claimed in claim 1 including an eyeshield of an operator's helmet onto which the high resolution display is projectable and a remote surface onto which the low resolution display is projectable.

3. A panoramic display apparatus as claimed in claim 1 including an eyeshield of an operator's helmet onto which the high and/or low resolution displays are projectable.

4. A panoramic display apparatus as claimed in claim 3 in which the remote surface is an interior surface of an aircraft canopy.

5. A panoramic display apparatus as claimed in claim 1 or claim 2 in which the projection means comprises a first projection system for projecting said high resolution display and a second projection system for projecting said low resolution display.

6. A panoramic display apparatus as claimed in claim 5 in which the first projection system comprises a first projector which presents an image alternately to the left and the right eye of an operator thereby to give a stereo image.

7. A panoramic display apparatus as claimed in claim 6 in which the projection system includes a LCD shutter located at or near a source of said image and passive polarisers before an operator's eyes.

8. A panoramic display apparatus as claimed in claim 5 in which the first projection system comprises a first and second projectors locatable and operable in combination to present an image to both eyes of an operator thereby to give a stereo image.

9. A panoramic display apparatus as claimed in claim 1 including one or more active matrix LCD arrays for projecting the high and/or low resolution displays.

10. A panoramic display apparatus as claimed in claim 9 in which the one or more active matrix LCD arrays is/are of a transparent type and locatable to form part or all of an eyeshield of an operator's helmet or is/are mountable on said eyeshield.

11. A panoramic display apparatus as claimed in any one of the preceding claims in which the first field of view extends up to or slightly beyond an operator's foveal boundary.

12. A panoramic display apparatus as claimed in any one of the preceding claims including graduation means for modifying the resolution of said first field at its periphery in a manner which matches the reduction in image resolution due to the human eye's acuity/eccentricity curve.

13. A panoramic display apparatus as claimed in any one of the preceding claims including a computation means for computing the

visual field location or locations of the high resolution first field or fields.

14. A panoramic display apparatus as claimed in any one of claims 3 to 11 in which the first projection system is mounted on a helmet to be worn by an operator and the second projection apparatus is mounted remote from said helmet.

15. A panoramic display apparatus as claimed in any one of the preceding claims in which the second field of view extends to form a full field of view of up to 360° about an operator's vertical and/or horizontal axis.

16. A panoramic display apparatus as claimed in any one of the above claims when used remotely to pilot a vehicle and/or in a robot/robotic system.

17. Two or more panoramic display apparatus as claimed in any one of the previous claims when linked to each other to form a network of visual displays for use with multiple operators.

18. Two or more panoramic display apparatus as claimed in claim 17 operable such that different information is presented in each operator's high resolution first field of view.

19. A panoramic display apparatus substantially as herebefore described with reference to and as illustrated in Figures 1 to 3 of the accompanying drawings.

20. A helmet when provided with a panoramic display apparatus as claimed in any one of claims 1 to 18.

15.

Patents Act 1977
Examiner's report to the Comptroller under Section 17 (The Search Report)

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H4T (TBAG,TBAS,TBAX,TCGA,TCGD, TCGX,TCHD,TCHX,TCJA)

(ii) Int Cl (Edition 5) G09B, H04N

Search Examiner
P J EASTERFIELD

Databases (see over)
(i) UK Patent Office

(ii) ONLINE DATABASES : WPI, INSPEC

Date of Search
3 FEBRUARY 1992

Documents considered relevant following a search in respect of claims 1 TO 20

Category (see over)	Identity of document and relevant passages	Relevant to claim(s)
Y	GB 2201069 A WALDERN	6,15-18
X	US 4634384 A NEVES ET AL	1,5,11, 12,13
X	US 4479784 A MALLINSON ET AL	1,5, 11-13
X	US 4421486 A BALDWIN ET AL	1,11,12
X	US 4348186 A HARVEY ET AL	1,4,11, 12
Y	New Scientist, 29 September 1990, page 32 "Vision technology heralds windowless fighter planes"	2,3, 14-16
X	Scientific American, July 1986, pages 90 to 97 "Flight simulation"	1,5, 11-13
Y	EP 0284389 A2 KAISER	2,3

Category	Identity of document and relevant passages	Relevant to claim(s)

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A: Document indicating technological background and/or state of the art.

P: Document published on or after the declared priority date but before the filing date of the present application.

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